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Chemically Modified Sago Fly Ash for Pb(II) Removal from Water

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Abstract. The use of agricultural by-products has been widely studied to develop effective and inexpensive adsorbent for heavy metal removal. In this study, sago (*M.sagu*) fly ash (FA) was chemically modified to afford an operational adsorbent for Pb(II) elimination from water. Chemical modification was carried out via acid-base treatment using NaOH and HCl. The chemically modified fly ash (MFA) was characterized via proximate, surface morphology, and functional groups' surface area analyses. The effects of adsorption parameters, namely, Pb(II) initial concentration, sorbent dosage and contact time on the eradication of Pb(II) by MFA was analyzed in batch experiments with Langmuir and Freundlich isotherms. Optimization of Pb(II) removal by MFA was studied via response surface methodology (RSM) approach. Results revealed that chemical modification has successfully enhanced the adsorptive properties of MFA (BET surface area: 231.4 m^2/g, fixed carbon: 55.83%). MFA exhibits better Pb(II) removal efficiency (90.8%) compared to FA (63.6%) at the following adsorption condition: Pb(II) initial concentration (5 ppm), contact time (30 min) and agitation speed (150 rpm). The adsorption of Pb(II) by FA and MFA fitted well with Freundlich isotherm (R^2>0.9). RSM study suggested that the optimum Pb(II) removal was 99.4% at the following conditions: Pb(II) initial concentration (20 ppm), contact time (2 h) and sorbent dosage (0.6 g/50 mL). The results concluded the potential optimum operational condition for Pb(II) removal from aqueous environment by MFA as a low cost adsorbent, at larger scale.

Introduction

Pb exists naturally in the environment but can occur at concentration exceeding the background value due to anthropogenic activities such as fossil fuels burning, mining, and manufacturing [1]. Pb(II) complexes are mostly ionic (e.g., Pb(II) SO_4^{2-}), while Pb(IV) incline to be covalent (e.g., $Pb(C_2H_5)_4$) [2]. Pb has various application in domestic, agricultural and industrial, including in devices to protect against X-rays, lead-acid batteries production, ammunitions and metal products [3].

Discharged heavy metals including lead (Pb) into water bodies cause a severe risk to human health and natural waters [4]. Exposure to Pb could occur *via* inhalation of dust particles contaminated with lead or aerosols, and ingestion from food, water, and paint [1]. Chronic Pb exposure give detrimental effects on central nervous system, the blood, vitamin D metabolism kidneys, and blood pressure while acute exposure causes gastrointestinal diseases, brain injury and kidney damage [1, 2]. Anemia, insomnia, headache, hallucination and renal injuries are also a few of the lethal symptoms [1, 3]. If releases into the water environment, Pb can amass and come in the food chain [3, 5].

Considering the severe health effects resulting from Pb pollution, several techniques for heavy metals removal from water bodies were explored in previous studies to remove Pb from water bodies. The methods included ion exchange, chemical oxidation, precipitation, coagulation, adsorption, sedimentation, osmosis, and filtration. However, these techniques are either inefficient for heavy metal removal at low concentration or involve high operational cost [6]. Eradication of heavy metals from natural water bodies by adsorption is a preferred technique as a result of economical operational cost, availability of waste material as feedstock for adsorbent preparation and effectiveness in removing heavy metal ions at low concentration [7].